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HAVE GLUONIC EXCITATIONS BEEN FOUND? [a]

PHILIP R. PAGE [b]

Department of Physics and Astronomy, University of Manchester,
Manchester M13 9PL, UK

New experimental information on the non–exotic $J^{PC} = 0^{-+}$ isovector seen at 1.8 GeV by VES yields convincing evidence of its excited gluonic (hybrid) nature when a critical study of alternative quarkonium assignments is made in the context of $^3P_0$ decay by flux–tube breaking. Production of this gluonic excitation via meson exchange is promising, although its two photon production vanishes.

Based on the phenomenological success[1] of the $^3P_0$ hadronic decay model, the decay modes of $Q\bar{Q}$ systems with an explicit gluonic excitation (hybrids) have been predicted[2] in a non–relativistic flux–tube model. Hybrids are predicted to have mass $1.8-1.9$ GeV[1], exactly in the region where a $J^{PC} = 0^{-+}$ isovector resonance has recently been seen[3]. The mass of this state also makes it a candidate for radial $3^1S_0\ Q\bar{Q}$ (π_{RR}). The decay of hybrids to "S+S"–wave mesons are expected[3] to vanish for identical mesons, and to be suppressed proportional to the difference of their "sizes" [2] for non–identical mesons. The dominant decay channel is hence to "P+S"–wave mesons.

VES[3] (and BNL[3]) detect a prominent resonance at ~ 1.8 GeV with width ~ 200 MeV in the "P+S" channels $\pi f_0(980)$, $\pi f_0(1300)$, $\eta a_0(980)$ and $(K\bar{K}\pi)_S$. On the other hand, the resonance is absent[3] in the "S+S" channels $\pi\rho$ and $\bar{K}K^*$. There is also possible[4] evidence for the (weak) mode $\pi f_0(1500)$ where the gluonic excitation de–exites to the gluonium candidate $f_0(1500)$. The foregoing clearly supports a hybrid interpretation. The predicted widths for a hybrid π_H at ~ 1.8 GeV are[2] (in MeV)

$$\pi f_0(1300) \sim 170;\ \pi f_2 \sim 5;\ \pi\rho \sim 30;\ \bar{K}K^* \sim 5;\ \pi\rho_R \sim 30$$
$$K^*\bar{K}^* \sim 0;\ \rho\omega \sim 0;\ \eta a_0 \sim 120;\ \pi f_0 \sim 160 \qquad (1)$$

where the last two modes assume that a_0, f_0 are $^3P_0\ Q\bar{Q}$.

The widths expected for π_{RR} are often distinctively *different*[2] from those of hybrids. *(i)* $\pi f_0(1300)$ is very much *suppressed* (<10 MeV over parameter space) relative to the prediction for π_H (Eq. 1) and either $\pi_{RR} \to \pi\rho, \pi f_2$ or $\bar{K}K^*$ whereas the data show that it is much larger than all of these. *(ii)* The same is true of $\bar{K}K_0^*(1430)$, which is threshold forbidden and manifested as $(K\bar{K}\pi)_S$. For π_H at 2 GeV $\bar{K}K_0^*$ is substantial

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[b] prp@a13.ph.man.ac.uk

at 200 MeV, consistent with the data, while for π_{RR} it is *suppressed* at $0-20$ MeV due to a node in the amplitude. The strong affinity of $K\bar{K} \to f_0(980)$ is probably responsible[2] for the observed strong[3] coupling to $\pi f_0(980)$. *(iii)* For π_{RR} the $\rho\omega$ channel is expected to be *prominent*[2] at $0-120$ MeV. In contrast, $\rho\omega$ vanishes for π_H (Eq. 1) independent of the wave functions assumed in the flux–tube model[2]. The $\rho\omega$ signal[4] builds up significantly below 1.8 GeV with width ~ 300 MeV, although a resonant signal has not yet been established. It is tempting to suggest that this indicates the detection of a seperate state, the π_{RR}, different from the 1.8 GeV π_H with width ~ 200 MeV. *(iv)* The possible existence of a seperate state is corroborated by the πf_2 channel which may also be distinctive. For π_H πf_2 is small (Eq. 1) whereas it is possibly *larger*[2] $(0-30$ MeV) for π_{RR}. The data[3] show a small πf_2 peak at 1.7 GeV, certainly below the 1.8 MeV region, though further analysis and data are required.

π_H and π_{RR} have in *common* that $\pi\rho$ is suppressed $(0-30$ MeV for π_{RR} due to a node) consistent with the data[3] which show no signal in the 1.7 to 2 GeV mass region. We suggest searching for coupling to the $\pi\rho$ channel, and further determinations of the mass and width of the state seen in $f_2\pi$ and $\rho\omega$.

At both VES and BNL the 0^{-+} was produced in $\pi^- N \to 0^{-+} N$ at high energy via either diffractive or ρ exchange. In the case of ρ exchange the width corresponding to the $\pi\rho$ vertex of π_H is bounded above[2] by 150 MeV, and is expected to be $\gtrsim 20\%$ of this value (see Eq. 1) since the ρ is off–shell and hence of potentially very different "size" than the on–shell π. This may lead to significant production of π_H in photoproduction on nuclei through π exchange, with the photon coupling to ρ (with upper bound 270 keV[2]); and would be especially significant at low energy facilities like an upgraded CEBAF where π exchange would be dominant.

An unfortunate corollary of the lack of coupling of π_H to $\rho\omega$ mentioned before, is that when the ρ and ω couple to photons, the two photon width and production of π_H vanish. In addition, the photoproduction of π_H via ρ or ω exchange vanishes[2]. Photon coupling via intermediate vector mesons is currently the only way of effecting flux–tube model photonic couplings for π_H.

References

1. E.S. Swanson *et al.*, *Phys. Rev.* D **52**, 5242 (1995); *Phys. Rev.* D **50**, 6855 (1994); ORNL-CTP-96-03.
2. P.R. Page *et al.*, *Nucl. Phys.* B **443**, 233 (1995); *Phys. Rev.* D **52**, 1706 (1995); OUTP-95-47P.
3. P.R. Page, D.I. Ryabchikov, D.P. Weigand, *Proc. of HADRON95*, ed. M.C. Birse *et al.*; D.V. Amelin *et al.*, *Phys. Lett.* B **356**, 595 (1995); *Jad. Fiz.* **59**, 1021 (1996).
4. Private communication, Y.A. Khokhlov, D.I. Ryabchikov, A.M. Zaitsev.